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# SELF-BALLASTED ELECTRODELESS FLUORESCENT LAMP

## TECHNICAL FIELD

[0001] The present invention relates to self-ballasted electrodeless fluorescence, and more particularly relates to self-ballasted electrodeless fluorescent lamps that can directly replace incandescent lamps.

## BACKGROUND ART

[0002] Recently, in view of global environmental protection and cost effectiveness, self-ballasted fluorescent lamps with electrodes, which have about five times higher efficacy than that of incandescent lamps, have been widely used as substitutes for incandescent lamps in houses, hotels and other places. In addition to the already existing self-ballasted fluorescent lamps with electrodes, self-ballasted electrodeless fluorescent lamps have also been studied in recent years. A feature of electrodeless fluorescent lamps is that they have a longer life than fluorescent lamps with electrodes, owing to the absence of electrode. Electrodeless fluorescent lamps are thus expected to become widespread in the future.

[0003] Such a self-ballasted electrodeless fluorescent lamp is disclosed in Japanese Laid-Open Publication No. 10-92391, for example. The self-ballasted electrodeless fluorescent lamp disclosed in the publication is illustrated in FIG. **6**.

[0004] The self-ballasted electrodeless fluorescent lamp **200** of FIG. **6** has as the entire device the shape of an incandescent lamp. More specifically, the lamp **200** is composed of a translucent discharge vessel **201**, a coil **203** inserted in a cavity portion **201a** of the discharge vessel **201**, and a power supply circuit **204**

for supplying alternating current to the coil **203**. The coil **203** is made up of a rod-shaped ferrite core and a winding. The winding is connected to the power supply circuit **204**. The power supply circuit **204** is formed and vertically placed on a circuit board on which a rectifier and a RF oscillator are provided in a vertical direction in the figure. The power supply circuit **204** is covered with a plastic case **205**. Input power to the power supply circuit **204** is supplied via a base **207** provided on part of the case **205**.

[0005] Mercury amalgam **206** and argon are enclosed as luminous substance in the discharge vessel **201**, while a phosphor layer **202** is formed on the inner surface of the discharge vessel **201**. The phosphor layer **202** changes ultraviolet light produced in the discharge vessel **201** into visible light.

[0006] However, to use electrodeless fluorescent lamps as substitutes for incandescent lamps, it is required to make the electrodeless fluorescent lamps closer to the incandescent lamps in terms of outer appearance and size. When a circuit board is placed vertically as in the above-mentioned disclosed electrodeless fluorescent lamp, it is difficult for the lamp to have an outer appearance and a size close to those of an incandescent lamp. Thus, in order to make the entire size almost equal to that of an incandescent lamp and then place the circuit board therein, the circuit board is preferably placed horizontally. In view of this, the present inventors have made an electrodeless fluorescent lamp in which a circuit board is placed horizontally and which is equal in size to an incandescent lamp.

[0007] The present inventors made various experiments using the lamp with the horizontally placed circuit board, and consequently found that when the lamp is operated, blackening is caused near the opening of the cavity portion of the discharge vessel and that the mercury reacts with the vessel wall and is

consumed. Such blackening becomes particularly severe when a phosphor, a protective coating, or the like is not applied. The fact that blackening occurs in an inner tube around the winding of an induction coil has been conventionally known as disclosed in Japanese Laid-Open Patent Publication No. 11-102667. However, the fact that blackening occurs in the vicinity of the opening of the cavity portion was found by the present inventors for the first time. The mechanism behind the occurrence of blackening of the inner tube around the winding was that a high electric field, resulting from a potential difference between adjacent turns of the winding, causes ions or the like in plasma to be attracted to, and come into collision with, the tube wall. On the other hand, the blackening occurring near the opening of the cavity portion, which was found by the present inventors, is caused in the vicinity of a connection wire that extends from the coil, and cannot be explained by the mechanism disclosed in the above-mentioned publication, because there are no such adjacent turns. If such blackening occurs, the mercury is held in the blackened portion, which causes the problem that the quantity of mercury in the discharge gas decreases over the course of time, so that the quantity of emitted light is reduced. Nevertheless, since the mechanism behind such blackening is unknown, countermeasures cannot be taken easily.

[0008] In view of these circumstances, the present invention was made, and an object thereof is to provide a self-ballasted electrodeless fluorescent lamp in which no blackening occurs near the opening of a cavity portion of a discharge vessel.

## DISCLOSURE OF INVENTION

[0009] A first inventive self-ballasted electrodeless fluorescent lamp includes: a luminous bulb in which a luminous gas containing at least mercury is enclosed and which has a cavity portion; an induction coil inserted in the cavity portion; a circuit board electrically connected to the induction coil; a case in which the circuit board is placed; and a base attached to the case and electrically connected to the circuit board, wherein a ballast circuit for supplying high frequency power to the induction coil is formed on the circuit board; the luminous bulb includes an approximately spherical outer tube and an inner tube defining the cavity portion; the circuit board is placed approximately horizontally when a central axis of the inner tube is placed vertically; a connection wire for electrically connecting the induction coil and the circuit board extends from one end of the induction coil into a region beyond an outer edge of the cavity portion, and is connected to the circuit board; and the connection wire is placed so as to be spaced apart from a sealing portion of the outer and inner tubes.

[0010] The self-ballasted electrodeless fluorescent lamp preferably further includes: a bobbin including a winding rod, around which the induction coil is wound, and a base portion, which is placed approximately at a right angle with respect to the winding rod and which supports the winding rod. And, preferably, the winding rod of the bobbin is inserted in the cavity portion; the base portion of the bobbin is disposed between the luminous bulb and the circuit board; and the connection wire extends from the one end of the induction coil so as to pass on or above a surface of the base portion which is located close to the luminous bulb.

[0011] In the self-ballasted electrodeless fluorescent lamp, part of the case preferably supports part of the luminous bulb, and the structure in which the

connection wire is disposed spaced apart from the sealing portion is preferably realized by lifting with the case the luminous bulb in a direction opposite to the base.

[0012] In the self-ballasted electrodeless fluorescent lamp, an upper end of the case preferably supports part of the luminous bulb in such a manner as to lift the luminous bulb in a direction opposite to the base, thereby allowing the connection wire to be disposed spaced apart from the sealing portion.

[0013] In the self-ballasted electrodeless fluorescent lamp, a protrusion, which supports part of the luminous bulb in such a manner as to lift the luminous bulb in a direction opposite to the base, is preferably formed on the base portion, which allows the connection wire to be disposed spaced apart from the sealing portion

[0014] In the self-ballasted electrodeless fluorescent lamp, a film capacitor, which is a circuit element included in the ballast circuit, is preferably disposed on a surface of the circuit board which is located close to the base

[0015] A second inventive self-ballasted electrodeless fluorescent lamp includes: a luminous bulb in which a luminous gas containing at least mercury is enclosed and which has a cavity portion; an induction coil inserted in the cavity portion; a circuit board electrically connected to the induction coil; a case in which the circuit board is placed; and a base attached to the case and electrically connected to the circuit board, wherein a ballast circuit for supplying high frequency power to the induction coil is formed on the circuit board; the luminous bulb includes an outer tube and an inner tube defining the cavity portion; the circuit board is provided with output terminals to the induction coil and input terminals from the base; the output and input terminals are disposed so as to be

separate from each other by 15 mm or more; a connection wire for electrically connecting the induction coil and the circuit board extends from one end of the induction coil into a region beyond an outer edge of the cavity portion, and is connected to the circuit board; and the connection wire is placed so as to be spaced apart from a sealing portion of the outer and inner tubes.

[0016] In one preferred embodiment, the connection wire and the sealing portion are spaced apart from each other by 0.3 mm or more.

[0017] In one preferred embodiment, the greatest length of the circuit board is 60 mm or less.

[0018] A phosphor or a protective coating is not applied to an inner wall of the sealing portion.

## BRIEF DESCRIPTION OF DRAWINGS

[0019] FIG. **1** is a partially cutaway view of a self-ballasted electrodeless fluorescent lamp in accordance with a first embodiment.

[0020] FIG. **2** is a partially cutaway view of a self-ballasted electrodeless fluorescent lamp in accordance with a second embodiment.

[0021] FIG. **3** is a view illustrating a circuit board surface that is located close to a luminous bulb in accordance with the first embodiment.

[0022] FIG. **4** illustrates the external appearance of the self-ballasted electrodeless fluorescent lamp of the first embodiment.

[0023] FIG. **5** is an exploded view of the self-ballasted electrodeless fluorescent lamp of the first embodiment.

[0024] FIG. **6** is a view schematically illustrating a conventional electrodeless fluorescent lamp.

## BEST MODE FOR CARRYING OUT THE INVENTION

[0025] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings. In the drawings, members that have substantially the same function will be identified by the same reference numerals for the sake of simplicity. The present invention is not limited to the following embodiments.

(First embodiment)

[0026] FIG. **1** is a partially cutaway view of a self-ballasted electrodeless fluorescent lamp in accordance with a first embodiment. The self-ballasted electrodeless fluorescent lamp illustrated in FIG. **1**, to which electric power can be supplied via the base, includes a ballast circuit.

[0027] The self-ballasted electrodeless fluorescent lamp includes a luminous bulb (bulb) **101** having a cavity portion (cavity), an induction coil **109** inserted in the cavity portion **120**, a circuit board **105** electrically connected to the induction coil **109**, a case **106** in which the circuit board **105** is placed, and a base **107** electrically connected to the circuit board **105**. In the luminous bulb **101**, a luminous gas containing at least mercury is enclosed. The base **107** is attached to the case **106**. The luminous bulb **101**, the induction coil **109**, the circuit board **105**, the case **106**, and the base **107** are integrated into one unit.

[0028] The induction coil **109** functions as a high frequency electromagnetic field generating means for generating a high frequency electromagnetic field within the luminous bulb **101**. The induction coil **109** is composed of a core (not shown) made of soft magnetic material (ferrite, for example) and a coil (excitation coil) **103** wound around the core. In this

embodiment, the core is placed within a cylindrical winding rod **104a** of a bobbin **104**, and the excitation coil **103** is also wound around the winding rod **104a**. The coil **103** of the induction coil **109** is electrically connected to the circuit board **105** via a connection wire **110**. On the circuit board **105**, a ballast circuit for supplying high frequency power to the induction coil **109** is formed.

[0029] In this embodiment, the luminous bulb **101** is composed of a substantially spherical outer tube **119** and an inner tube **120** that defines the cavity portion. The inner tube **120** is approximately cylindrical and has an opening in vicinity to the circuit board **105**. The outer tube **119** is in the shape of a so-called eggplant-shape. Examples of such a shape include the A-shape defined in JIS C 7710-1988.

[0030] As shown in FIG. **1**, the connection wire **110** is disposed spaced apart from a sealing portion **118** of the outer and inner tubes **119** and **120**. The luminous bulb **101** is supported by an upper end **106a** of the case **106**, which is the end opposing the base **107**. The case's upper end **106a** brings the luminous bulb **101** upward in such a manner that the connection wire **110** extending along the base portion **104b** of the bobbin **104** is spaced apart from the sealing portion **118** of the outer and inner tubes **119** and **120**. In this embodiment, the connection wire **110** extends from an end of the excitation coil **103** and is part of the excitation coil **103**. However, the connection wire **110** is not limited to being part of the excitation coil **103** in this manner, but a conductive member such as a copper wire, a copper sheet, or a corrosion-inhibitor-plated copper sheet may be used. In that case, such a connection wire may be electrically connected with the excitation coil **103**.

[0031] In this embodiment, the connection wire **110** is disposed spaced apart from the sealing portion **118** in order to prevent blackening of the inner wall of the sealing portion **118**. Although mechanisms behind the occurrence of such blackening have not been elucidated sufficiently, the present inventors' thinking concerning the mechanisms is as follows. More specifically, if the connection wire **110** is in contact with the sealing portion **118**, a potential difference occurring during lamp operation between plasma within the luminous bulb **101** and the connection wire **110** causes ions in the plasma to be attracted toward the connection wire **110** and then react with the material of the luminous bulb **101** to form mercury amalgam, thereby resulting in blackening. This is presumably due to the fact that the connection wire **110** is located too close to, and thus in contact with, the sealing portion **118**, because of the circuit design of the horizontally placed circuit board **105**, as will be described later. The problem of blackening can thus be solved by separating these members from each other. It would be considered that coating the inner wall of the luminous bulb **101** with a protective coating or a phosphor for suppressing the mercury reaction could prevent the blackening easily. However, since the sealing portion **118** is a portion in which the glasses fuse together, such a coating cannot be applied to the inner wall of the sealing portion **118**. Therefore, it is presumed that if the sealing portion **118** and the connection wire **110** are not separate from each other unlike in this embodiment, the sealing portion **118** will be easily blackened. The protective coating mentioned in this embodiment includes alumina particles, for example. Alumina particles suppress sodium diffusion from the glasses to react with the mercury.

[0032] Next, the structure of this embodiment will be further described in detail. The luminous bulb **101** is a vessel made of glass in which mercury as luminous material and a rare gas (e.g., krypton or argon) as a buffer gas are enclosed. The mercury, which is enclosed in the luminous bulb **101** in a liquid form or as amalgam, is heated by plasma produced during lamp operation, and the luminous bulb **101** has a mercury vapor pressure defined by that temperature. The internal volume of the luminous bulb **101** is, for example, from 100 to 270 $cm^3$. In the luminous bulb **101**, the mercury is enclosed in an amount of 2 to 10 mg, and the krypton is enclosed at a charged pressure of 50 to 300 Pa (at a temperature of 25 C°.)

[0033] A phosphor **102** for converting ultraviolet light produced by discharge within the luminous bulb **101** into visible light is applied to the inside (the inner wall) of the luminous bulb **101**. As described above, the inner tube **120** that is the cavity portion, into which part (i.e., the induction coil) of the high frequency electromagnetic field generating means is inserted, is formed in part of the luminous bulb **101**. It is thus easy to dispose the high frequency electromagnetic field generating means near the luminous bulb **101**. The luminous bulb **101** is formed of the cylindrical inner tube **120**, in which the excitation coil **103** can be disposed, and the approximately spherical outer tube **119** with the phosphor **102** applied thereto. The outer edge of the cavity portion of the inner tube **120** is melted with flame from a burner or the like and fused to part of the outer tube **119**. This fused portion is the sealing portion **118**, and the phosphor **102** is not applied to the sealing portion **118**. Since the fusing of this portion is carried out in the last stage of the fabrication of the luminous bulb **101**, it is not possible to apply the phosphor **102**.

[0034] Exemplary dimensions or the like of the luminous bulb **101** of this embodiment are as follows. The outer diameter of the central portion of the luminous bulb **101** (that is, the outer diameter of the greatest portion) is from 50 to 90 mm (thickness: about 1mm). The luminous bulb **101** is made of soda lime glass, for example, but may be made of borosilicate glass or the like. The height of the luminous bulb **101** and the height of the electrodeless fluorescent lamp including the base **107** are, for example, from 60 to 80 mm, and from 130 to 240 mm, respectively. The inner diameter of the inner tube **120** of the luminous bulb **101** is, for example, from 16 to 26 mm.

[0035] The ballast circuit connected to the excitation coil **103** located in the inner tube **120** supplies high frequency power to the excitation coil **103**. In other words, the ballast circuit is a high frequency power supply. In this embodiment, the high frequency electromagnetic field generating means is composed of the high frequency power supply, the ferrite core, and the excitation coil **103** wound around the ferrite core. As shown in FIG. **1**, to produce discharge in the luminous bulb **101**, the high frequency electromagnetic field generating means (in particular, the excitation coil **103** and the ferrite core) is provided in substantially the central portion of the luminous bulb **101**. More specifically, the ferrite core and the excitation coil **103** wound around the bobbin **104** are inserted in the inner tube **120** of the luminous bulb **101**. The circuit board **105**, on which the high frequency power supply (ballast circuit) is formed, is placed in the case **106**, and power is supplied from an external device via the base **107**. The base **107** is structured so as to be screwed into a socket, so that just screwing the base **107** into a socket allows the electrodeless fluorescent lamp to be electrically connected to an external power supply (for example, commercial power.)

Moreover, not only the electrodeless fluorescent lamp can be used just by screwing the base into a socket, but also the size and outer appearance of the lamp are close to those of an incandescent lamp. The electrodeless fluorescent lamp can therefore be put to the same uses as an incandescent lamp, and thus can directly replace an incandescent lamp.

[0036] The bobbin **104** is composed of the winding rod **104a** and the base portion **104b**. The excitation coil **103** of the induction coil **109** is wound around the winding rod **104a**. The base portion **104b** is disposed substantially at a right angle to the winding rod **104a** and supports the winding rod **104a**. The winding rod **104a** has a cylindrical shape and is inserted into the inner tube **120**, which is the cavity portion. The base portion **104b** extends from an end of the winding rod **104a** located close to the base **107**, substantially at a right angle with respect to the winding rod **104a**, so as to have the shape of a disc. The base portion **104b** is positioned between the luminous bulb **101**a and the circuit board **105**. The base portion **104b** is disposed approximately horizontally, when the central axis of the inner tube **120** is placed vertically.

[0037] The circuit board **105** is typically a printed circuit board. In this embodiment, like the base portion **104b** of the bobbin **104**, the circuit board **105** is disposed substantially horizontally when the central axis of the inner tube **120** is placed vertically. The base portion **104b** and the circuit board **105** are substantially parallel to each other. The space in the case **106** is divided into two by the circuit board **105**. The space on the circuit board **105** which is closer to the luminous bulb **101** is in close vicinity to high-temperature plasma in the luminous bulb **101**, and thus has a higher temperature than the space under the circuit board **105** which is close to the base **107**. Therefore, on the surface of the circuit

board **105** which is close to the luminous bulb **101**, relatively high-temperature-resistant circuit elements such as resistors are provided, while on the surface thereof close to the base **107**, low heat-resistant circuit elements such as a film capacitor **115** are disposed. The circuit elements provided on both surfaces and circuit wiring formed on the circuit board **105** form the ballast circuit. The reason why the film capacitor **115** is used as a capacitor is that as compared with a ceramic capacitor, change in the capacitance of the film capacitor **115** with temperature is smaller, and the film capacitor **115** produces a smaller amount of heat because its resistance is lower.

[0038] The connection wire **110**, which electrically connects the induction coil **109** and the circuit board **105**, extends from the one end of the induction coil **109** into a region beyond the outer edge of the cavity portion, and is connected to the circuit board **105**. More specifically, the connection wire **110** extends from the lower end of the excitation coil **103** of the induction coil **109**, along the winding rod **104a** to the base **107**, and then extends along the surface of the base portion **104b** which is located close to the luminous bulb **101**, in a direction going away from the central axis of the luminous bulb **101** (this central axis substantially agrees with the central axis of the inner tube **120**). The connection wire **110** then passes through the base portion **104b** near the outer edge of the base portion **104b**, and then extends to the circuit board **105** for connection with the circuit board **105**. In this embodiment, the region beyond the outer edge of the cavity portion is a region which is located farther away from the central axis of the inner tube **120** than the edge of the opening of the inner tube **120** is. More specifically, an example of such a region may be the sealing portion **118**. The connection wire **110** is disposed so as to separate from the sealing

portion **118** of the outer and inner tubes **119** and **120**. A distance **L** between the connection wire **110** and the outer surface of the sealing portion **118** is 0.5 mm. The distance **L** is preferably equal to or greater than 0.3 mm, and more preferably, the distance **L** is 0.5 mm or greater, in which case blackening can be prevented more reliably. Furthermore, it is preferable that insulating, high heat-resistant silicon or the like be applied to the gap between the connection wire **110** and the sealing portion **118**, because the distance **L** can then be reliably obtained.

[0039] The connection wire **110** extends along the base portion **104b** surface close to the luminous bulb **101** in the direction going away from the central axis of the luminous bulb **101**. Another structure would be considered, in which the connection wire **110** extending along the winding rod **104a** would pass through the base portion **104b** where the connection wire **110** reaches the base portion **104b**, and then would extend along the surface of the base portion **104b** which is close to the circuit board **105**, in a direction going away from the central axis of the luminous bulb **101**. However, this structure is not desirable because of the following reasons. On the circuit board **105** surface close to the base portion **104b**, there are the circuit wiring, the circuit elements, and protrusions of terminals of the circuit elements disposed on the opposite surface thereof. The connection wire **110** may thus be in contact with those members to be short-circuited or discharge.

[0040] FIG. **3** schematically illustrates the circuit board **105** surface that is located close to the luminous bulb **101**. The circuit board **105** is an octagonal sheet, and its greatest length **R** is 45 mm. The greatest length **R** is the greatest length within the face on which the ballast circuit is formed. The greatest length **R**, which is normally represented as the diameter of the circumscribed circle

of the circuit board **105**, is preferably 60 mm or less, so that the circuit board **105** can be horizontally placed within the case **106**. The circuit board **105** may be round or rectangular in shape. Circuit elements **131**, **131**, ... such as resistors are disposed on the surface of the circuit board **105**, and connected via circuit wires **132**, **132**, ... to the terminals **133**, **133**, ... of circuit elements formed on the opposite surface. Two output terminals **134**, **134** to the induction coil **109**, that is, connection portions to the connection wire **110**, are formed spaced apart from each other in the vicinity of the outer edge of the circuit board **105**. Input terminals **135**, **135** from the base **107** are formed substantially opposing the output terminals **134**, **134** with the center of the circuit board **105** between. A distance **D** between the output terminals **134**, **134** and the input terminals **135**, **135** is 23 mm. The distance **D** is preferably 15 mm or more.

[0041] The greater the distance **D** becomes the better, because if the output wiring to the induction coil **109** is located near the input wiring from a commercial power, high frequency noise will be sent to the commercial power. However, the size of the circuit board **105** is limited, and that size determines an upper limit.

[0042] Moreover, another constraint that the design of the ballast circuit is subject to is that the output wiring, to which high voltage is applied, should be disposed as far as possible away from the other wires. Due to this constraint, the output terminals **134**, **134**, which are the connection portions with the connection wire **110** to the induction coil **109**, are provided at the edge of the horizontally placed circuit board **105**. The connection wire **110** thus extends toward the cavity portion, from the edge of the circuit board **105** that is adjacent to the case **106**, and would be in contact with the sealing portion **118**, if no

countermeasure is taken. In view of this, in this embodiment, the luminous bulb **101** is lifted with the case's upper end **106a** to allow the connection wire **110** to extend along the bobbin's base portion **104b** so as to be spaced apart from the sealing portion **118**, thereby preventing blackening of the sealing portion.

[0043] The case **106** is made of heat-resistant material, and in this embodiment the case **106** is made of heat-resistant resin (for example, poly-butylene terephthalate). The case **106** can be made of material having excellent thermal conductivity (for example, metal) to have increased heat dissipation characteristics.

[0044] Next, the outer appearance and configuration of the self-ballasted electrodeless fluorescent lamp of this embodiment will be described with reference to FIGS. **4** and **5**.

[0045] The external appearance of the self-ballasted electrodeless fluorescent lamp of this embodiment is composed of the luminous bulb **101**, the case **106** and the base **107**. The case **106** has a threaded structure at one end, and the base **107** with a corresponding threaded structure can be attached to that one end of the case **106**. The ferrite core **117** is inserted in the bobbin **104**.

[0046] In this embodiment, one end of the bobbin **104** is located in the case **106**, and a heat sink **116** is attached to that one end of the bobbin **104**. The heat sink **116** is, for example, a sheet member with relatively high thermal conductivity (such as metal sheet, ferrite disc.) The heat sink **116** attached to the bobbin **104** suppresses temperature increase in the ferrite core **117**. If the ferrite core **117** exceeds the Curie temperature, the ferrite core **117** no longer functions as a magnetic material, so heat dissipation performed by the heat sink **116** can be a critical matter depending on the use conditions.

[0047] Furthermore, a circuit holder **108**, on which the circuit board **105** can be held, is integrated into the bobbin **104** by interfitting.

[0048] Next, it will be briefly described how the self-ballasted electrodeless fluorescent lamp of this embodiment operates. When commercial AC power is supplied to the high frequency power supply via the base **107**, the high frequency power supply **105** converts the commercial AC power into high frequency AC power, and supplies the high frequency AC power to the excitation coil **103**. The frequency of alternating current supplied by the high frequency power supply is from 50 to 500 kHz, for example, while the power supplied by the high frequency power supply is from 5 to 200 W, for example. Upon receiving the supply of the high frequency AC power, the excitation coil **103** forms a high frequency AC magnetic field in a space close to the excitation coil **103**. Then, an induction field occurs perpendicularly with respect to the high frequency AC magnetic field, causing the luminous gas inside the luminous bulb **101** to be excited to emit light. As a result, light emission in the ultraviolet range or the visible range can be obtained. The light emission in the ultraviolet range is changed to light emission (visible light) in the visible range by the phosphor **102** formed on the inner wall of the luminous bulb **101**. It should be noted that the lamp can be configured without forming the phosphor **102** so that the light emission in the ultraviolet range (or the light emission in the visible range) is utilized as it is. The light emission in the ultraviolet range is produced mainly from the mercury. More specifically, when a high frequency current is applied to the induction coil **109** located in close vicinity to the luminous bulb **101**, an induction field formed by magnetic force lines resulting from the electromagnetic induction causes collision between the mercury atoms and electrons in the luminous bulb

**101**, whereby ultraviolet light can be obtained from the excited mercury atoms.

[0049] Now, the frequency of the alternating current that the high frequency power supply supplies will be described. In this embodiment, the frequency of the alternating current supplied by the high frequency power supply is in a relatively low frequency range at or below 1 MHz (for example, from 50 to 500 kHz), as compared with 13.56 MHz or several MHz in the ISM band generally used in practical applications. The frequency in the low frequency range is used for the following reasons. First, if the lamp is operated in a relatively high frequency range, such as 13.56 MHz or several MHz, the size of a noise filter for suppressing line noise produced by the high frequency power supply is increased, resulting in an increase in the volume of the high frequency power supply. Moreover, if noise radiated or transmitted from the lamp is at high frequency, an expensive shield has to be used in order to meet the requirements of strict regulations specified in the law for high frequency noise, and this becomes a major obstacle in achieving cost reduction. On the other hand, when the lamp is operated in the frequency range from about 50 kHz to about 1 MHz, low-cost general-purpose products that are used as electronic components for general electronic equipment can be used as components of the high frequency power supply **105**, and in addition, those components can be small in size. This brings great advantages such as cost reduction and miniaturization. However, the self-ballasted electrodeless fluorescent lamp of this embodiment is not limited to operation at a frequency of 1 MHz or less and is capable of being operated at any frequency in a frequency range, within which 13.56 MHz or several MHz, e.g., fall.

[0050] In the configuration of this embodiment, the connection wire **110** that supplies high frequency power to the induction coil **109** is spaced apart

from the sealing portion **118** of the inner and outer tubes **120** and **119** of the luminous bulb **101**. This prevents occurrence of blackening of the inner wall of the sealing portion **118** when the self-ballasted electrodeless fluorescent lamp is operated.

[0051] Furthermore, in this embodiment, the upper end **106a**, which is part of the case **106**, supports and brings upward the luminous bulb **101**, such that the connection wire **110** is spaced apart from the sealing portion **118**. In this manner, the spacing can be realized easily without causing an increase in the number of components. And if each component has high dimension accuracy, the spacing can be reliably achieved just by attaching the case **106**. In this embodiment, the entire upper end **106a** of the case supports the luminous bulb **101**. Nevertheless, part of the case's upper end **106a** may support the luminous bulb **101**, or a supporting member, such as a protrusion, for supporting and bringing upward the luminous bulb **101** may be provided on the inner surface of the case **106**. It should be noted that the case **106** and the luminous bulb **101** may each have a fit portion so as to be fitted into each other.

[0052] It should be noted that the connection wire **110** that extends from the one end of the excitation coil **103**, along the surface of the bobbin's winding rod **104a** is also preferably spaced apart from the inner wall of the inner tube **120**. The distance is preferably 0.3 mm or more.

[0053] Moreover, the circuit board **105** may be placed vertically, if the connection wire **110** extends into a region beyond the outer edge of the cavity portion for connection with the circuit board **105**, and is spaced apart from the sealing portion **118**.

[0054] In addition, if the bobbin **104** is employed as in this embodiment, the excitation coil **103** and the ferrite core **117** can be disposed within the inner tube **120** of the luminous bulb **101** just by inserting into the inner tube **120** the bobbin **104** having the excitation coil **103** wound around the winding rod **104a**, and by inserting the ferrite core **117** into the winding rod **104a**. This allows the electrodeless fluorescent lamp to be assembled easily. If the bobbin **104** and the luminous bulb **101** are furnished with protrusions, claws, interfitting cavity portions, or the like for firmly securing the bobbin **104** and the luminous bulb **101** to each other, and are held together by interfitting, for example, a relative position between the induction coil **109** and the luminous bulb **101** can be kept constant, even if, e.g., vibration occurs. Moreover, the winding rod **104a** and the base portion **104b** are configured as one unit, which suppresses an increase in the number of components.

(Second embodiment)

[0055] With reference to FIG. **2**, a self-ballasted electrodeless fluorescent lamp in accordance with a second embodiment of the present invention will be described. The self-ballasted electrodeless fluorescent lamp of this embodiment differs from the lamp of the first embodiment only in terms of configuration for supporting the luminous bulb **101**. Therefore, this difference will only be explained.

[0056] In this embodiment, a luminous bulb **101** is supported and brought upward by protrusions **125** formed on a base portion **104b** of a bobbin **104**, whereby a connection wire **110** is spaced apart from a sealing portion **118**. This structure prevents, as in the first embodiment, occurrence of blacking of the inner wall of the sealing portion **118** when the self-ballasted electrodeless

fluorescent lamp is operated. There is a gap between a case's upper end **106a** and the luminous bulb **101**. This gap may be filled with a high-temperature resistant adhesive such as silicon.

[0057] The shape and number of protrusions **125** supporting the luminous bulb **101** are not particularly limited. The base portion **104b** may have a shape in which most part of the base portion **104b** rises except for its part on which the connection wire **110** extends. Furthermore, the luminous bulb **101** may be supported by both the case's upper end **106a** and the protrusions **125**. The shape of the outer tube **119** is not limited to the A-shape. For example, even if the outer tube **119** is approximately cylindrical in shape, the effects of the present invention can be attained so long as the connection wire **110** extends beyond the sealing portion **118**.

[0058] While the present invention has been shown in several forms as described in the preferable embodiments thereof, it is not so limited but susceptible of various changes and modifications.

[0059] The electrodeless fluorescent lamp disclosed in Japanese Laid-Open Publication No. 10-92391 (see FIG. **6**), in which the circuit board is placed vertically (in a direction parallel to the central axis of the luminous bulb) does not serve as a replacement for an incandescent lamp, because the case in which the circuit board is placed is increased in length, such that the electrodeless fluorescent lamp is not close to an incandescent lamp in terms of outer appearance and size. Moreover, because of the vertically placed circuit board, ambient temperature inside the case produced by high temperature plasma within the luminous bulb is almost the same anywhere in the case in spite of difference

caused by convention. It is thus difficult to use low heat-resistant circuit elements such as film capacitors.

[0060] In the present invention, the circuit board is placed horizontally, and the connection wire of the induction coil is spaced apart from the sealing portion of the inner and outer tubes of the luminous bulb. This allows the lamp to have such size and external appearance as to enable the lamp to become a replacement for an incandescent lamp, while suppressing blackening of the sealing portion.

## INDUSTRIAL APPLICABILITY

[0061] According to the present invention, by a simple structure, an electrodeless fluorescent lamp that has almost the same size and external appearance as those of an incandescent lamp can be obtained, and blackening of a sealing portion can be prevented. Accordingly, the present invention has a high industrial applicability in application of long-life self-ballasted electrodeless fluorescent lamps that can replace incandescent lamps.